Simulation of Tracer Fire

THE BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention relates generally to simulation of tracer fire. More particularly the invention relates to a method according to claim 1, a computer program according to claim 10, a computer readable medium according to claim 11 and a fire simulation means according to the preamble of claim 12.

The prior art includes numerous examples of simulator solutions wherein the path of a projectile fired from a weapon is simulated in order to imitate an actual combat situation in a manner being as realistic as possible, and thus enable adequate training of personnel for a corresponding live situation. For example, the U.S. patent 4,276,028 describes a gunnery training system, wherein a spot is projected onto a screen to represent a trace of a simulated projectile. A camera records an image on the screen as well as the spot's location in order to determine whether the simulated projectile hits an intended target or not. In addition to movements of the weapon, the spot's movement on the screen is influenced by the characteristics of a simulated terrain and ballistic parameters for the corresponding live projectile. This renders the calculation of a relevant spot projection onto the screen relatively complex.

Generally, the simulation equipment necessary to accomplish a projectile simulation wherein ballistic parameters are considered is relatively complex, bulky and/or heavy. Therefore, such solutions are primarily intended for stationary-, vessel- or vehicle

mounted weapons (i.e. relatively heavy weapons), and are not well suited for hand held weapons / firearms.

Moreover, the simulation of tracer ammunition being fired is associated with particular problems, since visual indications of the bullets themselves may here be used to control the fire towards an intended target, either as a complement or as an alternative to regular sight means attached to the weapon. In order to economize the ammunition usage, this type of fire control requires so-called burst firing. Although theoretically, any gun may be used to fire tracer ammunition, the vast majority of applications in which tracer ammunition is used concerns weapons with an automatic firing mechanism, such as machine-guns, light machine-guns, sub machine-guns and automatic or semi-automatic rifles. Therefore, the tracer fire simulator should be capable of handling automatic firing. However, there is yet no example of a simulator, which is suitable for simulating tracer fire from a man-worn automatic weapon.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to solve the problems above, and thus provide a lightweight and uncomplicated solution for simulating a situation wherein a relatively light weapon is used to combat a target by means of tracer ammunition.

According to one aspect of the invention, this object is achieved by a method of simulating tracer fire from a weapon by means of a non-ballistic fire simulation means attached thereon. The method involves projecting a light spot into a visual field of a user of the weapon, such that the light spot is observable by the user when firing at a target. The light spot indicates a non-ballistic estimation of a point of impact for a simulated bullet fired from the weapon. The light spot is turned on at a first point in time after triggering the weapon and turned off at a second

(and later) point in time after triggering the weapon. A switched-on interval between the first and second points in time at least partly overlaps a laser interval during which at least one light pulse is transmitted from the fire simulation means to simulate the bullet fired from the weapon to the target.

An important advantage attained by this method is that the user may perform an ample training in the process of efficiently directing actual tracer fire towards a target. The proposed method namely accomplishes a consistent imitation of the authentic situation with relatively simple means.

According to a preferred embodiment of this aspect of the invention, a light spot is prevented from being turned on during an inhibiting interval after that a previous light spot has been shown. This namely renders the fire simulation even more similar to an actual firing situation, where tracer bullets cannot be fired with a successful result other than in comparatively short bursts with a particular minimum interval separating them.

According to another preferred embodiment of this aspect of the invention, the switched-on interval is substantially longer than the laser interval, and more preferably, the first point in time coincides with a point in time at which a first light pulse is transmitted from the fire simulation means. Thereby, an even more authentic simulation is achieved because the light spot shown to the user then represents an accurate indication of the light pulse transmitted towards the target, i.e. the simulated bullet.

According to another preferred embodiment of this aspect of the invention, the first point in time and/or the second point in time are varied according to a stochastic algorithm. Consequently, the relationship between the firing operation and the switched-on interval becomes non-deterministic to some degree. This further increases the resemblance with the corresponding live fire.

According to yet a preferred embodiment of this aspect of the invention, the stochastic algorithm is adapted to reflect a bullet light-up parameter of a particular type of tracer ammunition. Naturally, this enhances the simulation's quality even more.

According to a preferred embodiment of this aspect of the invention, the estimated point of impact represents an endpoint of a line of sight from the muzzle, which is parallel to a longitudinal symmetry axis of the barrel. This is an advantageous non-ballistic estimation because it typically corresponds to the path which a one-way light pulse travels from the weapon to the target, i.e. a typical simulation method of wherein no data signal is fed back to the shot who fired the simulated bullet in question.

According to a preferred embodiment of this aspect of the invention, the switched-on interval represents 1 – 20 % of the bullet's estimated traveling time. Thereby, the actual tracer fire conditions are simulated to the user in a realistic manner.

According to another preferred embodiment of this aspect of the invention, the bullet's estimated traveling time is calculated by means of a non-ballistic algorithm, for instance exclusively being based on a measured distance between the weapon and the target, in conjunction with a predetermined and constant bullet velocity. Alternatively, the traveling time may be expressed as a fixed time, which is based on an average traveling time applicable at a typical shooting distance for the weapon in question. This strategy is advantageous, since thereby the simulation procedure is further simplified.

According to a further aspect of the invention the object is achieved by a computer program directly loadable into the internal memory of a computer, comprising software for performing the above proposed method when said program is run on a computer.

According to another aspect of the invention the object is

achieved by a computer readable medium, having a program recorded thereon, where the program is to make a computer perform the above-proposed method.

According to another aspect of the invention the object is achieved by the initially described fire simulation means, which is characterized in that it comprises a light projecting means and a laser unit. The light projecting means is adapted to project a light spot into the user's visual field, such that the light spot is observable by the user when firing at a target. The light spot indicates a non-ballistic estimation of a point of impact for a simulated bullet fired from the weapon. The light projecting means is adapted to turn on the light spot at a first point in time after triggering the weapon, and turn off the light spot at a second (and later) point in time after triggering the weapon. The laser unit is adapted to, during a laser interval after triggering the weapon, transmit at least one light pulse in a direction of the target to simulate the bullet fired from the weapon to the target. A switched-on interval for the light spot, i.e. between the first and second time instances, here at least partly overlaps the laser interval.

According to a preferred embodiment of this aspect of the invention, the light projecting means includes a light source and a wavelength selective mirror surface. The light source is adapted to produce visible light with a relatively narrow wavelength spectrum. The wavelength selective mirror surface is adapted to reflect light within the relatively narrow wavelength spectrum, and permit transmission of a predominance of electromagnetic energy representing visible light of other wavelengths. Furthermore, the light source and the wavelength selective mirror surface are arranged in relation to one another, such that the light spot occurs in the user's visual field when he/she aims at the target. This relatively uncomplicated design accomplishes a comparatively realistic imitation of the actual tracer fire conditions, and is therefore desirable.

According to another preferred embodiment of this aspect of the invention, the light projecting means and the laser unit are calibrated to one another, such that the light spot indicates a point to which the at least one light pulse is transmitted. Thus, the calibration between the fire simulation means and the weapon is made less critical, and an adequate tracer fire simulation can be accomplished even though there may be a slight mismatch, for instance between the weapon's sight means and the fire simulation means.

According to a first alternative preferred embodiment of this aspect of the invention, the fire simulation means is adapted to be integrated into a standard sight means of the weapon, which is adapted for aiming live bullets. Thus, an even more compact simulation solution is obtained.

According to a second alternative preferred embodiment of this aspect of the invention, the fire simulation means is instead adapted to represent an additional sight means to any standard sight means of the weapon for aiming live bullets. Thereby, a high degree of freedom is attained without charging the live weapon with any extra load. Naturally, such a design is also advantageous, particularly when the simulation means is to be attached to a weapon which lacks a live-sight means of its own (e.g. a machine-gun exclusively intended for tracer fire).

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now to be explained more closely by means of preferred embodiments, which are disclosed as examples, and with reference to the attached drawings.

Figure 1 illustrates a turn on-/turn off-procedure for a light spot which indicates a point-of-impact for a simulated bullet according to an embodiment of the invention,

Figure 2 shows a schematic side elevation view of a proposed fire simulation means,

Figure 3 illustrates, by means of an example, a user's visual field according to an embodiment of the invention,

Figure 4 illustrates the combat situation in figure 3 wherein a weapon fires simulated tracer fire towards a target, and

Figure 5 shows a flow diagram, which illustrates the general method according to an embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

It is presupposed that a fire simulation means is attached to a weapon whose tracer fire against a target is to be simulated. According to the invention, the effects of the simulated fire is represented by means of a light spot displayed in the visual field of a user of the weapon, such that the light spot is observable by the user when firing at the target with the weapon. Thus, the light spot is intended to indicate a point-of-impact for a simulated bullet fired from the weapon. A turn on- and turn off-procedure for such a tracer bullet simulating light spot according to an embodiment of the invention is illustrated in figure 1. A diagram here represents a turned-on condition for the light spot by means of a first state "ON" and a corresponding turned-off condition by means of a second state "OFF". A time line t is represented along the horizontal axis of the diagram.

A firing operation, typically initiated by depressing a trigger on the weapon, is presumed to take place at a point in time t_0. Thus, at this time instance t_0, a simulated bullet is triggered. Typically, this means that at least one light pulse is transmitted from a laser unit in the fire simulation means. Neither the laser unit nor the light pulses are subject to the present application, and will therefore not be described in detail here. However, the light pulses generally include a weapon identity, such that

simulator equipment associated with any potential targets may be activated by the pulses and may determine whether they were hit by the particular bullet or not.

Moreover, it is normally advisable to delay the transmission of the light pulses until the gas turbulence produced by the firing has cleared up sufficiently to allow the light pulses from the laser unit to pass through to the target. Therefore, a laser interval T_{laser} during which at least one light pulse is transmitted from the fire simulation means is initiated at a first time instance t_1 (say 50 milliseconds) after the triggering instance t_0. The laser interval T_{laser} is relatively short (a few milliseconds) and ends at a somewhat later time instance t_L.

In order to simulate the fired bullet to the shot (i.e. the user of the weapon), the light spot is projected into his/her visual field to represent the light trace, which the corresponding live ammunition causes when being fired. Under normal conditions, such a light trace is visible only during a relatively short period of the time that it takes for the bullet to reach its point of impact. If say, the bullet's traveling time (or time of flight) from the weapon's muzzle to the point of impact is in the range of 1-2 seconds, the light trace may be visible for a period of 10-200 milliseconds. In fact, it is generally the case, that the bullet's light-up time represents 1 – 20 % of the bullet's traveling time. Naturally, the relationship between the light-up time and the traveling time depends on the shooting distance, such that for example, at extremely short distances no light trace at all may be visible, whereas at relatively long shooting distances, a somewhat longer trace may be seen.

According to the invention, the light spot is turned on at a first point in time t_1 after triggering a simulated bullet t_0 and turned off at a second, and later, point in time t_2. Consequently, the light spot is "ON" during a switched-on interval t_{ON} between the first point in time t_1 and the second point in time t_2, and thereby simulates to the shot the characteristics of a live tracer bullet. In

order to accomplish a realistic simulation and to enable a suitable training for the shot, the switched-on interval t_{ON} should indicate to the shot where the simulated bullet actually goes. Therefore, the switched-on interval t_{ON} should overlap the laser interval T_{laser}. For example, both intervals may be initiated at the same time, i.e. at the first time instance t_1. Preferably, the switched-on interval t_{ON} is also substantially longer than the laser interval T_{laser}. Furthermore, it is preferable that the switched-on interval t_{ON} is substantially shorter than the estimated time of flight t_{shoot}.

According to a preferred embodiment of the invention, another light spot cannot be generated until an inhibiting interval T_{block} (where $T_{block} >> t_{ON}$) has lapsed after that a previous light spot was turned on. For example, the inhibiting interval T_{block} may set a 1 – 2 seconds delay between the first time instance t_1 and an earliest possible subsequent light spot "ON"-state at a third instance in time t_3. Thereby, two consecutive light spots cannot be presented at an unrealistically short interval from one another. This, in turn, results in that the fire simulation becomes more similar to an actual firing situation, where tracer bullets cannot be fired with a successful result, other than in comparatively short bursts with a particular minimum interval separating them.

The diagram represents a time of flight T_{flight} from the triggering instance t_0 to a point in time t_{imp} when a live bullet corresponding to the simulated bullet would hit an object (either an intended target or another entity which stops the bullet) at a geographical point of impact. According to a preferred embodiment of the invention, the switched-on interval t_{ON} is substantially shorter than the estimated time of flight t_{flight}, for instance constitute 1 – 20 % of the estimated time of flight t_{flight}.

The estimated time of flight t_{flight}, in turn, may be determined in many different ways. However, for reasons of simplicity, a non-ballistic algorithm is used according to the invention. The

simplest strategy is, of course, to apply a fixed estimated traveling time for all simulated bullets fired by a particular weapon, regardless of the shooting distance or any other circumstances. Alternatively, the traveling time may be calculated based on a measured (straight-line) distance between the weapon and the target, in conjunction with a predetermined and constant bullet velocity.

Preferably, the authenticity of the simulation may be further enhanced by varying either the period between the triggering instance t_0 and the first point in time t_1, the triggering instance t_0 and the second point in time t_2, or both, according to a stochastic algorithm. Namely thereby, the relationship between the triggering operation and the switched-on interval becomes less deterministic and more similar to the behavior of the corresponding live ammunition.

Moreover, the parameters of the stochastic algorithm itself may be varied to simulate various behaviors of different types of tracer ammunition, such as the bullets' light-up time.

Further details pertaining to the relationships between the location of the light spot and an estimated point of impact for a simulated bullet fired from the weapon will be discussed below with reference to figures 2 – 4.

Figure 2 shows a schematic side elevation view of a fire simulation means 200 according to an embodiment of the invention for simulating the effects of tracer fire to a user, which is adapted to be attached to a weapon, such as an automatic firearm. The simulation means 200 includes a main scope tube 205 containing an objective lens, erector lenses and eyepiece lenses for receiving incoming light and displaying an image in a user's (i.e. shot's) visual field 240 of any entities against which the weapon is aimed. Moreover, the simulation means 200 includes a processing unit 210, a light-spot arrangement 220, 221, 222, 230 and a laser unit 260 for transmitting at least one

light pulse P_L to simulate a fired bulled to a target.

The processing unit 210 is adapted to receive a fire signal F indicative of a triggering operation performed by the weapon, i.e. when the user pulls the trigger to fire one or more simulated bullets. In response to the fire signal F, the processing unit 210 generates a control signal to a light source 220 in the light-spot arrangement according to the procedure described above, such that the light source 220 is turned on during a time period overlapping a laser interval during which the laser unit 260 transmits at least one light pulse P_L to represent the fired bullet. The light-spot arrangement may also include a diaphragm 221 and a projection lens 222 to accomplish a light spot on a wavelength selective mirror surface 230 having a desired characteristics (with respect to e.g. size and intensity).

Preferably, the light source 220 produces visible light with a relatively narrow wavelength spectrum (e.g. a particular nuance of red), and the wavelength selective mirror surface 230 is adapted to reflect light within this particular spectrum, and permit transmission of a predominance of electromagnetic energy representing visible light of other wavelengths. The mirror surface 230 is arranged relative the light-spot arrangement, such that the light from the light source 220 is reflected on the mirror surface 230 and occurs in the user's visual field 240 as a light spot when he/she aims at a target with the weapon. The wavelength selective mirror surface 230 may be formed by a number of alternative optical elements, such as a flat mirror or an internal face of a prism.

According to the invention, the light spot indicates an estimated point of impact for a simulated bullet fired from the weapon, representing an endpoint of a line of sight from the weapon, i.e. a straight line from the muzzle which is parallel to a longitudinal symmetry axis of the barrel. Naturally, this merely constitutes a coarse approximation of the actual trajectory of a fired live bullet. However, it is normally sufficient for the purpose of

simulating the effects of tracer ammunition to a firearms shot in order to adjust the aiming of the weapon for a subsequent round/burst.

According to a preferred embodiment of the invention, the light-spot arrangement 220, 221, 222, 230 and the laser unit 260 are calibrated to one another, such that the light spot indicates a point to which the at least one light pulse P_L is transmitted. Thus, the calibration between the fire simulation means and the weapon is made less critical, such that an adequate tracer fire simulation can be accomplished even though the sights may be very coarse or there may be a slight mismatch, for instance between the weapon's sight means and the fire simulation means.

It is preferable that the fire simulation means 200 includes an attachment means 250, such as a dovetail, for enabling it to be mounted on a weapon. Moreover, the fire simulation means 200 may be integrated into a standard sight means of the weapon adapted for aiming live bullets.

Alternatively, it may represent an additional sight means to any standard sight means of a weapon for aiming live bullets. The latter is preferable if the fire simulation means 200 is primarily intended to be mounted on weapons, which either completely lack sight means, or predominantly are aimed by means of tracer fire.

Figure 3 illustrates, by means of an example according to an embodiment of the invention, a user's visual field 240 when firing at a target 310. In analogy with the above, a light spot 320 occurs in the visual field 240 during a switched-on interval T_{ON} overlapping a laser interval during which at least one light pulse is transmitted that simulates a fired bullet. Thereby, by firing a number of simulated bullets, for instance consecutively in a burst, the user may control the fire towards the intended target 310, such that any later fired simulated bullets are likely to hit

the target 310.

Figure 4 also illustrates the combat situation shown in figure 3, wherein a weapon 400 is used to fire simulated tracer fire towards the target 310. The fire simulation means 200 according to the invention is mounted on the weapon 400, such that the effects (i.e. light traces) of the simulated fire are observable as light spots by a user of the weapon 400 when firing at the target 310. Each light spot indicates an estimated point of impact for a simulated bullet fired by the weapon 400. The estimated point of impact represents an endpoint 420 of a line of sight 430 from the weapon's 400 muzzle 415, which is parallel to a longitudinal symmetry axis of the weapon's 400 barrel 410.

In order to sum up, the general method for simulating tracer fire according to the invention will now be described with reference to figure 5. A first step 510, of this procedure examines whether a trigger signal has been received. If so, a step 520 follows. Otherwise the procedure loops back and stays in the step 510. The step 520 starts a first and a second timer to set the first point in time t_1 and the second point in time t_2 respectively (see figure 1). As discussed above, one or more of the first and second points in time t_1 and t_2 may be controlled by means of a stochastic algorithm. This is equivalent to allocating the values of the first and second timers based on the result of a stochastic algorithm. However, in any case, the runtime of the second timer always exceeds the runtime of the first timer, such that the second point in time t_2 occurs later than the first point in time t_1.

Subsequently, a step 530 checks whether the first timer has expired, and if so a step 540 follows. Otherwise the procedure loops back and stays in the step 530. The step 540 turns on the light spot, typically by means of a first control signal to a light source. Then, a step 560 checks whether the second timer 560 has expired, and if so the procedure continues to a step 570. Otherwise, it loops back and stays in the step 560.

The step 570 turns off the light spot, typically by means of a second control signal to the light source. Finally, the procedure loops back to the step 510 again in order to investigate whether a trigger signal still is present.

Hence, if a user pulls the trigger for a period of time during which two or more consecutive live bullets would have been fired by the weapon, i.e. so that an automatic fire burst is produced, the proposed method generates a repeated sequence of light pulses in the user's visual field to represent a plurality of simulated bullets. The interval between two consecutive switched-on intervals of the light spot is namely at least equal to the difference in time between the triggering instance, detected in the step 510, and the expiry of the first timer, detected the step 530. This interval may be set equal to the inhibiting interval T_{block} mentioned above with reference to figure 1. Thereby, the invention may simulate automatic tracer fire in a realistic manner.

All of the process steps, as well as any sub-sequence of steps, described with reference to the figure 5 above may be controlled by means of a programmed computer apparatus. Moreover, although the embodiments of the invention described above with reference to the drawings comprise computer apparatus and processes performed in computer apparatus, the invention thus also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of source code, object code, a code intermediate source and object code such as in partially compiled form, or in any other form suitable for use in the implementation of the process according to the invention. The carrier may be any entity or device capable of carrying the program. For example, the carrier may comprise a storage medium, such as a ROM (Read Only Memory), for example a CD (Compact Disc) or a semiconductor ROM, or a magnetic recording medium, for example a floppy disc or hard disc. Further, the carrier may be a transmissible carrier such as an electrical or optical signal which may be conveyed via

electrical or optical cable or by radio or by other means. When the program is embodied in a signal which may be conveyed directly by a cable or other device or means, the carrier may be constituted by such cable or device or means. Alternatively, the carrier may be an integrated circuit in which the program is embedded, the integrated circuit being adapted for performing, or for use in the performance of, the relevant processes.

The term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers, steps or components. However, the term does not preclude the presence or addition of one or more additional features, integers, steps or components or groups thereof.

The invention is not restricted to the described embodiments in the figures, but may be varied freely within the scope of the claims.